A Proposal for a Three Detector Short-Baseline Neutrino Oscillation Program in the Fermilab Booster Neutrino Beam

Part VI: Coordination and Schedule

January 8, 2015

CONTENTS

I. INTRODUCTION

This proposal is being submitted jointly by three separate scientific collaborations: ICARUS-WA104, LAr1-ND, and MicroBooNE. Each has an existing organizational structure with an existing scientific mission. The preparation of the proposal is the result of a collaborative effort between the collaborations guided by the SBN task force and the Fermilab SBN coordinator. The mandate of the task force and the five associated working groups ends with the submission of the proposal. In the desired event that this proposal is accepted, a new organizational structure will be necessary to ensure a successful program. The form of the future SBN organization has been the topic of discussions between the leadership of the three collaborations, the management of Fermilab, the management of INFN, and the management of CERN. Since these discussions have not concluded, we only present here some general observations. The new structure will need to ensure the following will happen:

1. the MicroBooNE experiment (E-974) carries out the already approved physics program as an independent collaboration;

2. the ICARUS-T600 detector is refurbished, transported to Fermilab, installed and commissioned;

3. the LAr1-ND detector is designed, constructed, installed and commissioned;

4. the required infrastructure (e.g. buildings, cryogenics, computing) are constructed or purchased and installed;

5. necessary common activities, like cosmic taggers, are designed, constructed and installed;

6. necessary reconstruction and analysis software for a multi-detector oscillation analysis is designed, developed and tested;

7. necessary improvements of the booster neutrino beam for an increased neutrino intensity are studied in detail to provide implementation before the starting of data taking.

All of these activities must take place simultaneously in a very short time-frame.

We expect that the three collaborations will continue to exist in whatever new structure is created for some time to come. The collaborations each have a clear unique role to play in delivering the first three of the above items. The fourth is the responsibility of Fermilab, as host laboratory, in collaboration with international partners such as CERN and INFN. The collaborations have a vested interest in delivery of this infrastructure so the organization must account for that. The last items are clearly of interest to members of all three collaborations.

The three scientific collaborations have worked together through the task force and working groups for the past eight months. As discussed in Part 1 of this proposal, the successful analysis of data from all three detectors for the oscillation analyses will require a coordinated effort on common reconstruction and analysis tools. This effort should start well in advance of start of operations. Joint reconstruction and oscillation analysis group(s) could form the nucleus of the future scientific organization. It will be natural for members of the SBN physics working groups and other relevant people from the collaborations to initiate this effort.

In the following sections we describe the schedule and funding for completion of the components listed above.

II. SCHEDULE

Initial data-taking with all three detectors operational is foreseen in spring 2018. By this time, the MicroBooNE detector will already have been operational with beam for several years. All steps to prepare the near and far detectors must be accomplished by this time, including design and construction of the near and far buildings, construction of cryostats and cryogenics, preparation of the ICARUS-T600 detector, construction of the near detector, detector installation and commissioning. The proposed schedule is very tight, but with a good level of coordination, it is judged to be feasible. Table I shows the high level set of milestones.

Milestone	Date
Far Detector building: final CE requirements and start final design	Nov 2014
Far Detector: T600 at CERN and refurbishing starts	Dec 2014
Submit SBN proposal to PAC	Dec 2014
Near Detector: Start preliminary design of TPC and installation	Dec 2014
PAC Review of SBN Proposal	Jan 2015
Near Detector cryostat: Start preliminary design	Jan 2015
Cryogenic plants: Start preliminary design	Jan 2015
Draft MOUs: e.g. Fermilab-INFN, Fermilab-CERN, Fermilab-CH-NSF	Feb 2015
Near Detector building: final CE requirements and start final design	Feb 2015
Independent Review of Near Detector, ND Cryostat and ND Cryogenics (CD-1/2 like)	May 2015
Independent Review of Far Detector refurbishing, cryogenics and installation planning	May 2015
Far Detector building: ground breaking	May 2015
Near Detector building: ground breaking	Aug 2015
Independent review of near detector production readiness	Nov 2015
Independent review of far detector production readiness	Nov 2015
Near Detector building: beneficial Occupancy	Sept 2016
Independent review of installation readiness for near and far detectors	Oct 2016
Far Detector building: beneficial Occupancy	Nov 2016
Near Detector cryostat: start installation	Nov 2016
Far Detector cryostat: start installation	Dec 2016
Far Detector: ICARUS-T600 ready at CERN for transport	Dec 2016
Near and Far Detector Buildings Complete	Jan 2017
Far Detector: start T600 installation	Mar 2017
Near Detector: Start LAr1-ND installation	April 2017
Far Detector: T600 Installed	May 2017
Near Detector: LAr1-ND Installed	July 2017
Far Detector: Cryogenic plant complete	Aug 2017
Near Detector: Cryogenic plant complete	Oct 2017
Start detectors cooling and commissioning	Nov 2017
Start data taking with beam	Apr 2018

TABLE I: *Overall Milestones for construction, installation and initial commissioning of the Short Baseline Neutrino Program*

Figure 1 shows the schedule in a summary format for near and far detector, pointing to the

start of data taking with beam to April 2018.

A. Near Detector Schedule

The schedule for design, fabrication, assembly and installation of the components of near detector is shown in Table II. A detailed resource loaded schedule for these tasks is under development and will be presented at the Independent review in the Spring of 2015.

TPC	Start	End
Requirements Documents		Feb 2015
Preliminary Design	Nov 2014	Jan 2015
Design Review		Mar 2015
Final Design	Jan 2015	Jun 2015
Production Readiness Review		Jul 2015
Fabrication (APAs, CPAs, FCA)	Jul 2015	Apr 2016
QA (Cold Tests)	Apr 2016	Jun 2016
Delivery to Fermilab by		Sep 2016
Assembly	Sep 2016	Feb 2017
Installation	Apr 2017	Jul 2017
Cold Electronics		
Requirements Documents		Mar 2015
Preliminary Design	Jan 2015	Sep 2015
Design Review		Oct 2015
Final Design	Oct 2015	Mar 2016
Production Readiness Review		Mar 2016
Fabrication	Apr 2016	Jun 2016
Assembly	Jul 2016	Sep 2016
Delivery to Fermilab by		Oct 2016
Installation	Nov 2016	Jul 2017
Light Detector		
Preliminary Design	Dec 2014	Mar 2015
Choice of technology		Mar 2015
Final Design	Apr 2015	Sep 2015
Production Readiness Review		Oct 2015
Fabrication	Nov 2015	May 2016
Assembly	Jun 2016	Nov 2016
Delivery to Fermilab by	Dec 2016	Dec 2016
Installation	Jan 2017	Jul 2017
Laser Calibration	Start	End
Requirements Documents		Jan 2015
Preliminary Design		Complete
Final Design	Mar 2015	Jul 2015
Production Readiness Review		Jul 2015
Fabrication	Jul 2015	Jan 2016
Assembly	Jan 2016	Jun 2016
Delivery to Fermilab	Jun 2016	Aug 2016
Installation	Jul 2017	Sep 2017

TABLE II: *Summary of LAr1-ND detector component schedules*

B. Far Detector Schedule

As for the Near Detector, all steps to prepare ICARUS-T600 must be accomplished by this time, from the submission of the initial design report to start-up of the civil engineering work, construction of cryostats and cryogenics, transportation to site, and overall detector preparation and commissioning.

movement to CERN	Start	End
Laser survey		Complete
Transportation Frames		Complete
Disassembly work		Complete
TPC transport to CERN		Complete
Equipment transport to CERN		Complete
Building 185 preparation		Complete
T600 cryostats		
Engineering cold vessel + production	Jan-13	Sep-16
Engineering cold vessel supports		complete
Engineering warm vessel	Dec14	May15
GTT preliminary study		complete
Procurement extruded Aluminum	Dec14	May15
Assembly cold vessels	Jun15	Dec16
Procurement Warm Vessel + supports	Dec14	Mar16
Procurement Insulation	Jan15	Dec16
Warm vessel assembly	Oct15	Jun16
Insulation installation	Sep16	Dec16
Cold shields	Jan15	Dec16

TABLE III: *Summary of ICARUS-WA104 detector overhauling schedules*

The proposed schedule is illustrated in tables III and IV. It is a very tight schedule, but with a good level of coordination, it is judged to be feasible, as it is based on the previous experience gained with the Pavia test run in 2001 [1] and the Gran Sasso Physics Run, 2010-2013 [2]. Moreover most of the milestones are related to operations at CERN in the frame of the WA104 program, therefore a periodic verification of the project development will be assured. The ICARUS-T600 detector has already be transported to CERN.

C. Infrastructure Schedule

Table VI shows the schedule for the design, procurement and installation of the cryogenic systems for the near and far detectors. Table V shows the schedule for the design, procurement and installation of the near detector cryostat. The schedule for the far detector cryostat is included in the schedule for the far detector (Table III). The schedule for the construction and installation of Cosmic taggers for both near and far detector are presented in Tab. VIII.

Table VII shows the schedule for design and construction of the far detector and near detector buildings. Also shown is the schedule for the associated site preparation work. The

T600 cryogenics		
Reorganization and packaging	Jan-15	Dec-16
New hardware	May-15	Oct-16
Tests and maintenance	Jan-15	Mar-16
Cryo group at CERN	Mar-15	Oct-16
Vacuum test	Aug-16	Nov-16
Cold gas test (if possible)	Nov-16	Dec-16
T600 refurbishing		
TPC-1 Cabling TPC internal	Dec-14	Aug-15
TPC-1 New PMT procurement	Oct-14	Aug-15
TPC-1 New PMT installation	Mar-15	Sep-15
TPC-1 installation in cold vessel	Nov-15	Jan-16
TPC-2 Cabling TPC internal	Jan-16	Oct-16
TPC-2 New PMT procurement	Oct-15	Jul-16
TPC-2 New PMT installation	Feb-16	Oct-16
TPC-2 installation in cold vessel	Nov-16	Dec-16
New electronics	Mar-14	Dec-16
Final assembly into the warm vessel	Dec-16	Jan-17
T600 controls and tests	Start	End
Slow controls hardware	Jan-16	Nov-16
Slow controls software	Jan-16	Nov-16
DAQ system	Jan-16	Nov-16
Tests of Slow controls	Jan-16	Nov-16
Tests of DAQ	Jan-16	Nov-16

TABLE IV: *Summary of ICARUS-WA104 detector overhauling schedules*

site preparation includes elements that will be completed after construction of the buildings is completed.

Near Detector Cryostat	Start	End
Requirements Documents		Dec 2014
Preliminary Design	Jan 2015	May 2015
Production Readiness Review		Jun 2015
Final Design	Jul 2015	Nov 2015
Procure membrane cryostat materials	Dec 2015	Jun 2016
Procure support structure	Dec 2015	Apr 2016
Procure top plate	Feb 2016	Oct 2016
Delivery to Fermilab (structure)	May 2016	Jun 2016
Delivery to Fermilab (top plate)	Oct 2016	Nov 2016
Assembly	Jul 2016	Nov 2016
Installation	Dec 2016	Jan 2017
Safety Review Complete		Nov 2017

TABLE V: *Summary of schedules for design, procurement and installation of the near detector cryostat.*

Near Detector LAr Cryogenics	Start	End
Requirements Documents		Dec 2014
Preliminary Design	Jan 2015	Jun 2015
Production Readiness Review		Aug 2015
Procurement Documents	Sep 2015	Mar 2016
Final Design	Apr 2016	Jun 2016
Fabrication	Jul 2016	Apr 2017
Delivery of skids to Fermilab	Jun 2017	Jul 2017
Installation	May 2017	Oct 2017
Safety Review Complete		Nov 2017
Near Detector LN_2 Cryogenics		
Requirements Documents		Dec 2014
Preliminary Design	Jan 2015	Jun 2015
Production Readiness Review		Aug 2015
Procurement Documents	Sep 2015	Nov 2015
Final Design	Dec 2015	Mar 2016
Fabrication	Apr 2016	Dec 2016
Delivery to Fermilab	Jan 2017	Feb 2017
Installation	Mar 2017	Jul 2017
Safety Review Complete		Nov 2017
Far Detector LAr Cryogenics		
Existing Cryogenics at CERN		Nov 2014
Reorganization and Packaging (Part 1)	Jan 2015	Jun 2015
Production Readiness Review		Aug 2015
Reorganization and Packaging (Part 2)	Sep 2015	Dec 2016
New Hardware	May 2015	Oct 2016
Test and Maintenance	Jan 2015	Mar 2016
Vacuum Test	Aug 2016	Nov 2016
Cold Test	Nov 2016	Dec 2016
Delivery to Fermilab	Jan 2017	Feb 2017
Installation	Mar 2017	Aug 2017
Safety Review Complete		Sep 2017
Far Detector LN_2 Cryogenics		
Requirements Documents		Dec 2014
Preliminary Design	Jan 2015	Jun 2015
Production Readiness Review		Aug 2015
Final Design	Sep 2015	Nov 2015
Procurement Documents	Dec 2015	Mar 2016
Fabrication	Apr 2016	Dec 2016
Delivery to Fermilab	Jan 2017	Feb 2017
Installation	Mar 2017	Jul 2017
Safety Review Complete		Sep 2017

TABLE VI: *Summary of schedules for design, procurement and installation of the cryogenic systems for the near and far detectors.*

Site Preparation	Start	End
Preliminary Design	Oct 2014	Nov 2014
Requirements Documents		Nov 2014
Final Design	Jan 2015	Mar 2015
Bidding and Procurement	Apr 2015	May 2015
Construction	May 2015	Jan 2017
Far Detector Building		
Preliminary Design	Jun 2014	Sep 2014
Requirements Documents		Nov 2014
Final Design	Nov 2014	Mar 2015
Final Design Review		Mar 2015
Bidding and Procurement	Apr 2015	May 2015
Construction	May 2015	Jan 2017
Beneficial Occupancy		Nov 2016
Near Detector Building		
Preliminary Design	Jun 2014	Sep 2014
Requirements Documents		Feb 2015
Final Design	Feb 2015	May 2015
Final Design Review		May 2015
Bidding and Procurement	Jun 2015	Aug 2015
Construction	Aug 2015	Nov 2016
Beneficial Occupancy		Sep 2016

TABLE VII: *Summary of civil construction schedules for the site preparation, far detector building and near detector building*

Cosmic Tagger		
Requirements Documents		Jan 2015
Preliminary Design	Nov 2014	Mar 2015
Final Design	Mar 2015	Jul 2015
Production Readiness Review		Jul 2015
Fabrication of strips	Jul 2015	Jun 2016
Assembly bottom plane	Mar 2016	Jun 2016
Assembly side planes	Jun 2016	Dec 2016
Assembly top planes	Mar 2016	Apr 2017
Delivery of bottom to Fermilab	Jun 2016	Aug 2016
Delivery of sides to Fermilab	Dec 2016	Feb 2017
Delivery of top to Fermilab	Apr 2017	Jun 2017
Installation bottom	Nov 2016	Nov 2016
Installation sides	Sep 2017	Sep 2017
Installation top	Dec 2017	Dec 2017

TABLE VIII: *Summary of construction and installation of the Cosmics tagger*

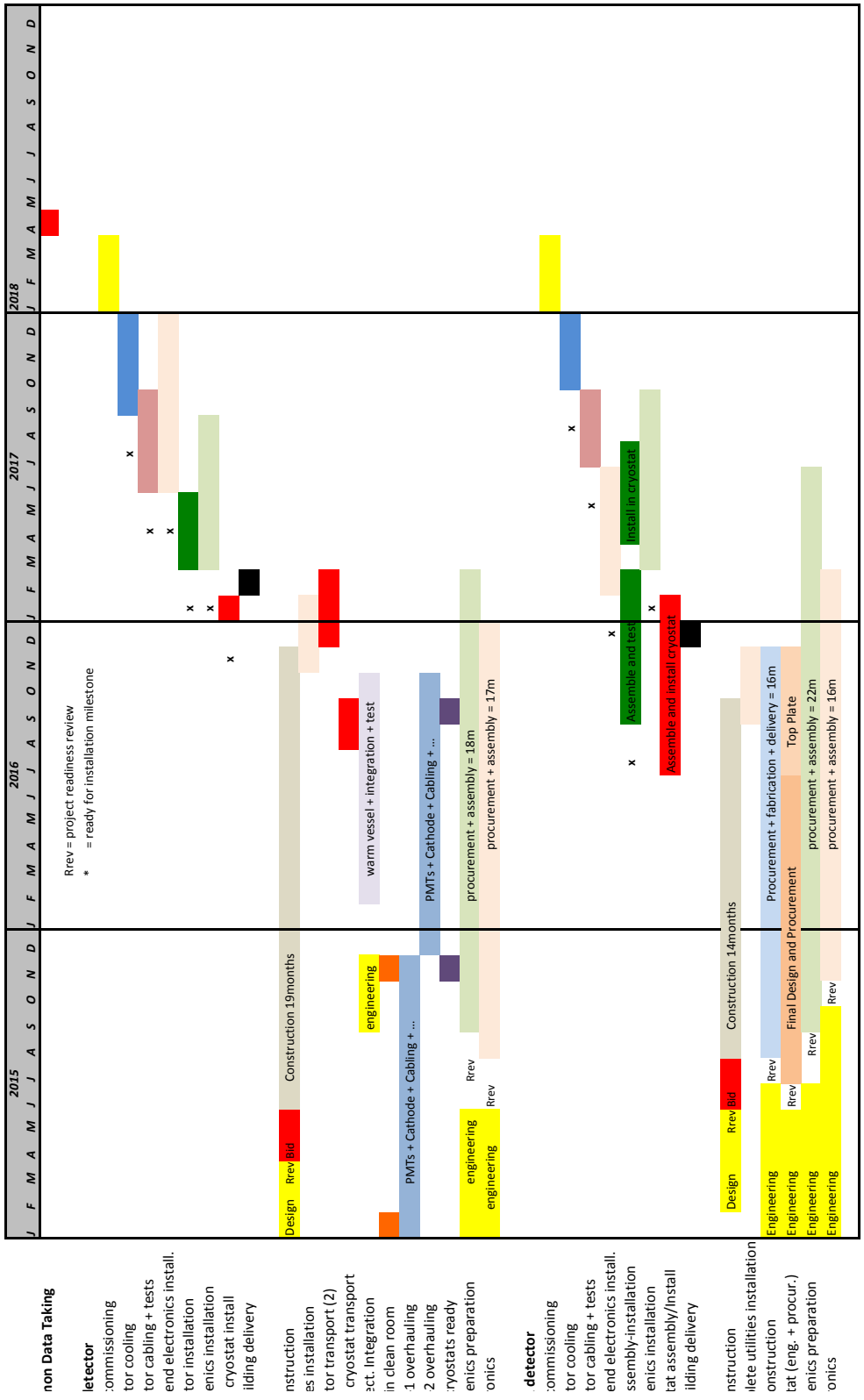

FIG. 1: *Overall summary schedule for the far and near detector construction*

III. PROGRAM FUNDING

The funding of the overall program will have several sources from the U.S. and Europe. As the host laboratory, Fermilab will be responsible for the design, construction and outfitting of the buildings for the near and far detectors. This construction will be funded as three separate DOE General Plant Projects (GPPs):

- Site preparation - extension of utilities, preparation of roads etc
- Far detector building
- Near detector building

The maximum cost of a GPP ($10M) is a significant constraint for the design of the far detector building, however a it has been shown that at least two different solutions fit within the constraint, provided external funding for ancillary items (such as shielding) is found. The design and construction starts of the far and near detector facilities are staged to match expected funding profiles yet provide beneficial occupancy in time for detector installation. A total of $14.8M has been allocated in the Fermilab budget plan in FY2014-2016 for the design and construction of the buildings. This is sufficient for construction based on estimates of the conceptual designs.

Costs for cryostats and cryogenics infrastructure will be shared between Fermilab, CERN, and INFN. CERN and Fermilab will share in the design and construction of the near detector cryostat and cryogenics. CERN and INFN will have primary responsibility for the far detector cryostat and cryogenics. Fermilab's role in the far detector will focus primarily on the LN_2 delivery and support of the safety documentation process. CERN and INFN will act with in-kind contributions of engineering and procurements which can be done in Europe (e.g. near detector cryostat material, LAr cryogenic plants components, and existing ICARUS-T600 infrastructure components). A draft of the sharing of these responsibilities is shown in Table IX. The overhauling of the ICARUS-T600 at CERN is financed by the WA104 collaboration through a Memorandum Of Understanding between CERN and INFN. Transport of components to FNAL will be financed in the same way. Figures 2 and 3 are extracted from the MOU signed between INFN and CERN for the overhauling work. A summary is also given in Table X, the costs are quoted in swiss francs (CHF).

The construction of the new near detector (e.g. TPC, light detection) will be financed by several funding agencies including the DOE, US-NSF, CERN, UK-STFC, and Switzerland. Table XI shows the expected breakdown of responsibilities by funding source and responsible institutions. The exact sharing of responsibilities will be defined in a dedicated MOU or MOUs, which will be monitored by Fermilab. Funding has already been secured for design and construction of the LAr1-ND TPC through a US-NSF MRI grant to Univ. of Chicago, Syracuse Univ., and Yale Univ. and through a UK-STFC grant to Lancaster Univ., Univ. of Liverpool, Univ. of Manchester, Unv. of Sheffield, and Univ. College London[1]. Funding from the DOE through Fermilab started with fiscal year 2015 (Oct 2015). Additional funding proposals have been submitted by the Univ. of Bern (CH-NSF) and Columbia Univ. (US-NSF). As described in Part 2 of this proposal, there are several alternatives under consideration for the light detection system. The institutional responsibilities for this system will be determined when a technology choice is made.

[1]Part of a grant to multiple UK institutions for LBNF and SBN activities

LAr/GAr System	Service Type	Responsible
LAr Receiving Facility	Cryo	FNAL
LAr/GAr Transfer Lines	Cryo/Non Cryo	FNAL
GAr/H2 Supply and Transfer Lines	Non Cryo	FNAL
GAr Filtration	Non Cryo	shared
GAr Analyzers	Non Cryo	shared
Condenser	Cryo	shared
LAr handling and purification System	Cryo	shared
Inside piping	Cryo/Non Cryo	shared
GAr handling system	Non Cryo	shared
LN2 System	Service Type	Responsible
LN2 Receiving Facility	Cryo	FNAL
LN2 Transfer Lines	Cryo	FNAL
GN2 returns	Non Cryo	INFN/CERN
LN2/GN2 handling system	Cryo/Non Cryo	INFN/CERN
LN2 Distribution Facility	Cryo	INFN/CERN
LN2 Pumping Station	Cryo	INFN/CERN
Services	Cryo	shared
Ancillary Items	Service Type	Responsible
Process Controls	Non Cryo	FNAL
Design/Drafting	Non Cryo	shared
Smart P&IDs	Cryo/Non Cryo	shared
Safety aspects of cryogenic installation at Fermilab	Cryo	FNAL

TABLE IX: *Draft proposal for CERN, FNAL and INFN responsibilities, for what concerns the management of the cryogenic system maintenance and on-site logistics. The keyword 'shared' refers to tasks to be undertaken jointly by all groups.*

The sharing of operation costs for the SBN detector will be defined in due time in a dedicated agreement, shared by all partners. The boundary between construction and operations will need to be defined in the initial agreements for the construction. The typical Fermilab boundary includes detector commissioning costs as part of operations.

Main Operation	Total(kCHF)	INFN	CERN
Movement to CERN	1227	723	504
Cryostats	3951	1869	2082
Cryogenics	1108	0	1108
Refurbishing[a]	6731	4263	2468
Controls and tests	115	0	115
Total	13132	8060	5072

[a]The new electronics will separately addressed by INFN

TABLE X: *Overall summary of INFN/CERN funding for ICARUS-T600 overhauling operations at CERN.*

Detector System	Funding Source	Institutions
TPC Integrated Design	UK-STFC & US-NSF	Lancaster, Liverpool, Manchester, Sheffield, BNL, Chicago, Syracuse, Yale
TPC CPAs	UK-STFC	Liverpool
TPC APAs	UK-STFC & US-NSF	Manchester, Sheffield, Chicago, Syracuse, Yale
TPC Field Cage	US-NSF	Yale
Cold Electronics	DOE	BNL
Warm Electronics	US-NSF[a]	Columbia
Light Detection	US-NSF & DOE	TBD
Laser Calibration	CH-NSF[a]	Bern
Cosmic Tagger	CH-NSF [a,b]	Bern
Detector Integration and Installation	DOE	FNAL lead

[a]Grant proposal submitted
[b]plan to combine with far detector effort

TABLE XI: *Overall summary of funding sources and institutional responsibilities for construction of the near detector.*

#	item	cost KCHF	INFN (%)	CERN (%)	start	end	CERN / INFN costs
	T600 movement to CERN						
1	Laser survey	16	0	100	Oct-13	Oct-13	16
2	Transp. Frames engineering	23	100	0	Oct-13	Dec-13	23
3	2 x Transp. frames procurement	250	0	100	Mar-14	Aug-14	250
4	Disassembly work + TPC extraction	575	100	0	Oct-13	Dec-14	575
5	1st TPC transport to CERN	69	0	100	Nov-14	Nov-14	69
6	2nd TPC transport to CERN	69	0	100	Dec-14	Dec-14	69
7	Equipment transport to CERN	125	100	0	Nov-13	Dec-14	125
8	185b preparation	100	0	100	Nov-13	Dec-14	100
	total	1227					504 /723
	T600 cryostats						
9	Engineering cold vessel + production follow up	200	25	75	Jan-13	Sep-16	150 / 50
10	Engineering cold vessel supports	24	0	100	Jan-13	Jun-14	24
11	Engineering warm vessel (1PJAS)	120	0	100	Jan-14	Oct-15	120
12	GTT preliminary study	31	0	100	May-13	Dec-13	31
13	Procurement Extruded Aluminium	450	100	0	Dec-14	May-15	450
14	Procurement Cold Vessels	1225	100	0	Dec-14	Sep-16	1225
15	Vessel components transport to CERN	69	0	100	Jul-15	Aug-16	69
16	Cold Vessels final assembly at CERN	350	0	100	May-15	Dec-16	350
17	Procurement Warm Vessel + support	725	0	100	Dec-14	Mar-16	725
18	Procurement Insulation	447	0	100	Jan-15	Nov-15	447
19	Warm vessel assembly	88	0	100	Oct-15	Jun-16	88
20	Insulation installation	156	50	50	Sep-16	Dec-16	78 / 78
21	Cold shields	66	100	0	Jan-15	Dec-16	66
	total	3951					2082/1869

FIG. 2: *Signed MOU table between CERN and INFN for the ICARUS detector overhauling at CERN*

			/T600 cryogenics				
22	Reorganization and packaging	313	0	100	Jan-15	Dec-16	313
23	New hardware	425	0	100	May-15	Oct-16	425
24	Tests and maintenance	250	0	100	Jan-15	Mar-16	250
25	Cryo group at CERN (1 PJAS)	120	0	100	Mar-15	Oct-16	120
26	Vacuum test	0	50	50	Aug-16	Nov-16	0
27	Cold gas test	0	50	50	Nov-16	Dec-16	0
	total	1108					1108/0
			T600 refurbishing				
28	Clean room in b185 + expert manpower	391	20	80	Oct-14	Nov-16	313/78
29	Crane drivers and internal transport	200	0	100	Oct-14	Dec-16	200
30	TPC-1 Cabling TPC internal	31	100	0	Dec-14	Aug-15	31
31	TPC-1 New PM procurement	750	100	0	Oct-14	Aug-15	750
32	TPC-1 New PM installation	39	100	0	Mar-15	Sep-15	39
33	TPC-1 installation in cold vessel	30	50	50	Nov-15	Jan-16	15/15
34	TPC-2 Cabling TPC internal	31	100	0	Jan-16	Oct-16	31
35	TPC-2 New PM procurement	750	100	0	Oct-15	Jul-16	750
36	TPC-2 New PM installation	39	100	0	Feb-16	Oct-16	39
37	TPC-2 installation in cold vessel	30	50	50	Nov-16	Dec-16	15/15
38	Final assembly into the warm vessel	0	50	50	Dec-16	Jan-17	
39	Veto counters procurement and preassembly	1200	50	50	Aug-15	Dec-16	600 / 600
40	R&D for a future upgrade	240	50	50	Jan-15	Dec-16	120 / 120
	total	3731					1263/2468
			T600 controls and tests				
41	Team manpower (1 PJAS)	90	0	100	Sep-15	Dec-16	90
42	Slow Controls hardware	25	0	100	Jan-16	Nov-16	25
43	Slow Controls software	0	50	50	Jan-16	Nov-16	0
44	DAQ system	0	50	50	Jan-16	Nov-16	0
45	Tests of Slow Controls	0	50	50	Jan-16	Nov-16	0
46	Tests of DAQ	0	50	50	Jan-16	Nov-16	0
	total	115					115
	Gran Total T600 (KCHF)		**INFN Contrib.**		**CERN Contrib.**		
	10132		**5060**		**5072**		

FIG. 3: *Signed MOU table between CERN and INFN for the ICARUS detector overhauling at CERN*

Table XII details the ICARUS-WA104 contribution to the SBN program in terms of personnel for a three-year activity plan both from CERN and INFN. This includes scientific as well as technical resources. The temporary manpower needed at CERN for several aspects of the overhauling, like crane drivers and experts manpower (Project Associates: PJAs), is already quoted in the MOU figures in CHF and it is in addition to the FTE quoted figures.

ICARUS-WA104 T600 group	Manpower (FTE)
Gran Sasso Science Insitute (GSSI)	1
INFN, Sezione di Catania	2.5
INFN, Sezione di Milano	1.5
INFN, Sezione di Milano Bicocca	0.5
INFN, Laboratori Nazionali del Gran Sasso (LNGS)	1
INFN, Sezione di Napoli	0.5
INFN, Sezione di Padova	7
INFN, Sezione di Pavia	6
CERN Neutrino group and services	9
Total	30

TABLE XII: *Details of ICARUS-WA104 T600 contribution to SBN activities in terms of manpower (FTE) for a three-year activity plan.*

The contributions of personnel for near detector and infrastructure (by Fermilab) are being accumulated as part of the development of the resource loaded schedule. A preliminary accounting should be available prior to the PAC meeting.

Table XIII provides a preliminary list of the personnel contributions for the near detector in average FTE/year for construction and installation period. Both scientific and technical resources are included but not labor provided through contracted services. Contributions from some institutions are still pending (tbc). The Fermilab effort includes work on infrastructure such as cryogenics but excludes design and construction of the buildings. Effort on the MicroBooNE experiment is not included.

The last row lists common support effort by Fermilab including support for far detector infrastructure. The Fermilab effort on beamline improvements have not been included at this time. Needs for common support of data acquisition software and reconstruction software will be developed in the coming months.

LAr1-ND Group	Average FTE/yr
Univ. of Bern	4
Univ. of Chicago	2
Columbia Univ.	2.3
Indiana Univ.	1
MIT	2
Syracuse Univ.	1.5
Yale Univ.	1.5
Cambridge, Lancaster, Liverpool, Manchester, Sheffield, UCL	5.9
ANL	1.5
BNL	7
FNAL	12.5
LANL	2.7
LAr1-ND Total	43.9

General FNAL SBN Effort	5.5

TABLE XIII: *Contributions to near detector development by institution in FTE/year averaged over three years. The last row shows effort by Fermilab in areas of common support or infrastructure support for the far detector.*

[1] S. Amerio *et al.* (ICARUS Collaboration), "Design, construction and tests of the ICARUS T600 detector," Nucl.Instrum.Meth. **A527**, 329–410 (2004).

[2] C. Rubbia, M. Antonello, P. Aprili, B. Baibussinov, M. Baldo Ceolin, *et al.*, "Underground operation of the ICARUS T600 LAr-TPC: first results," JINST **6**, P07011 (2011), arXiv:1106.0975 [hep-ex].